United States Patent [19]

Sunaga et al.

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[45] **Date of Patent: Feb. 23, 1988**

[54] **METHOD OF COLD DRAWING SEAMLESS METAL TUBES EACH HAVING AN UPSET PORTION ON EACH END**

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[73] Assignee: **Sanwa Kokan Kabushiki Kaishas**, Yokohoma, Japan

[21] Appl. No.: **858,179**

[22] Filed: **May 1, 1986**

Related U.S. Application Data

[62] Division of Ser. No. 599,825, Apr. 13, 1984, Pat. No. 4,606,212.

[51] **Int. Cl.**[4] **B21C 1/24**

[52] **U.S. Cl.** **72/283**; 72/285; 72/276

[58] **Field of Search** 72/283, 285, 291, 276, 72/260, 265

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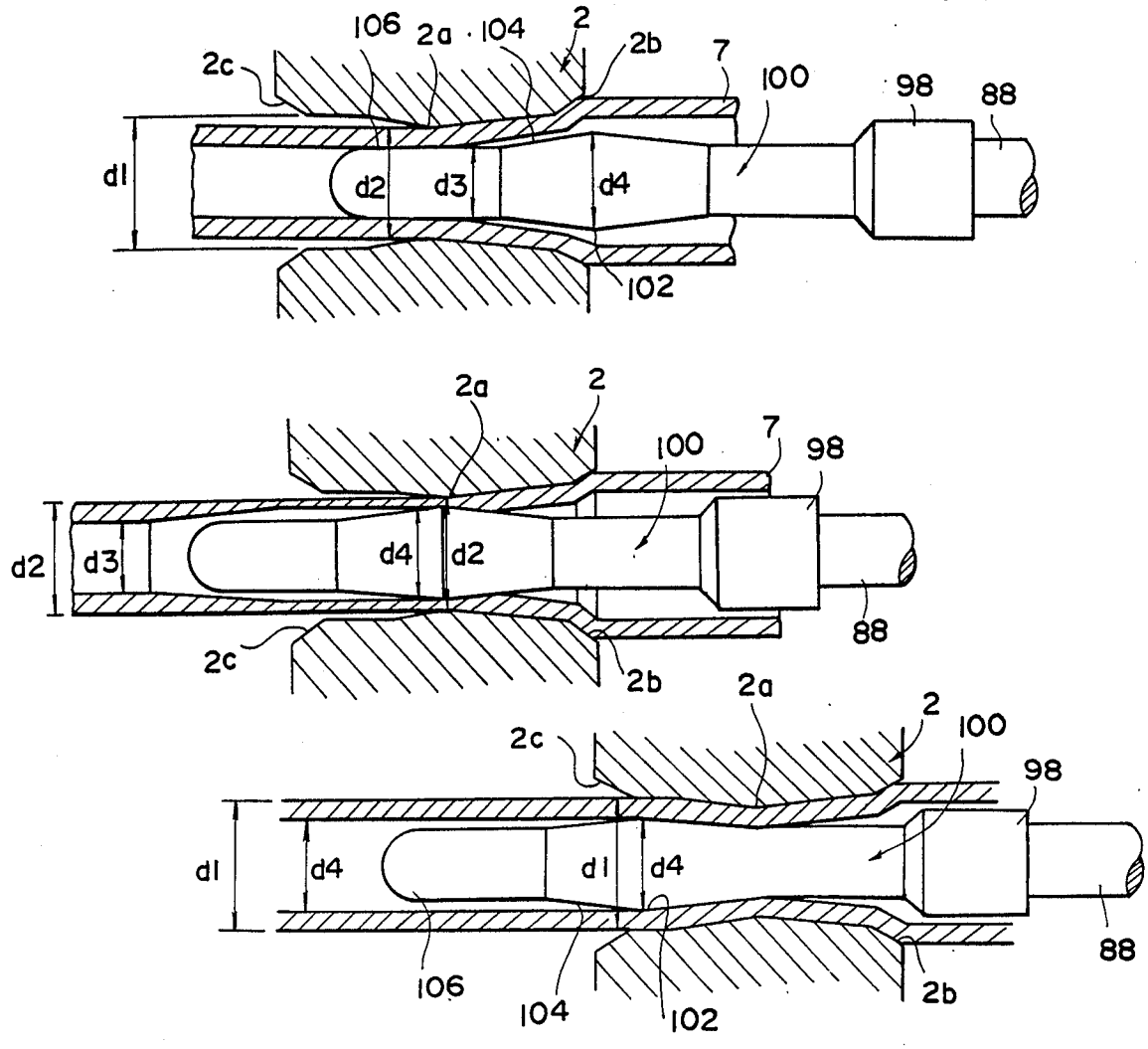
Primary Examiner—Daniel C. Crane

[57] **ABSTRACT**

A method of cold drawing seamless metal tubes each having an upset portion on each end. A draw bench used for carrying out the method of this invention comprises a die control device, a plug control device including a plug having large and small diameter bearing portions and a draw unit. The die control device and the plug control device are movable with each other for changing a cross sectional reducing area between the reducing die and the plug. The method is characterized in that the cross sectional reducing area between the reducing die and the plug is preferably changed in accordance with the desired forms of a mother tube to be drawn by longitudinally transferring the reducing die and the plug and fixing them at the selected positions.

2 Claims, 18 Drawing Figures



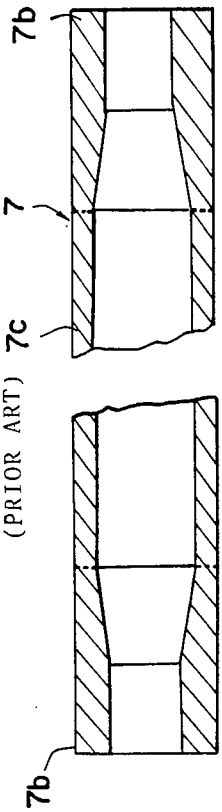


FIG. 1
(PRIOR ART)

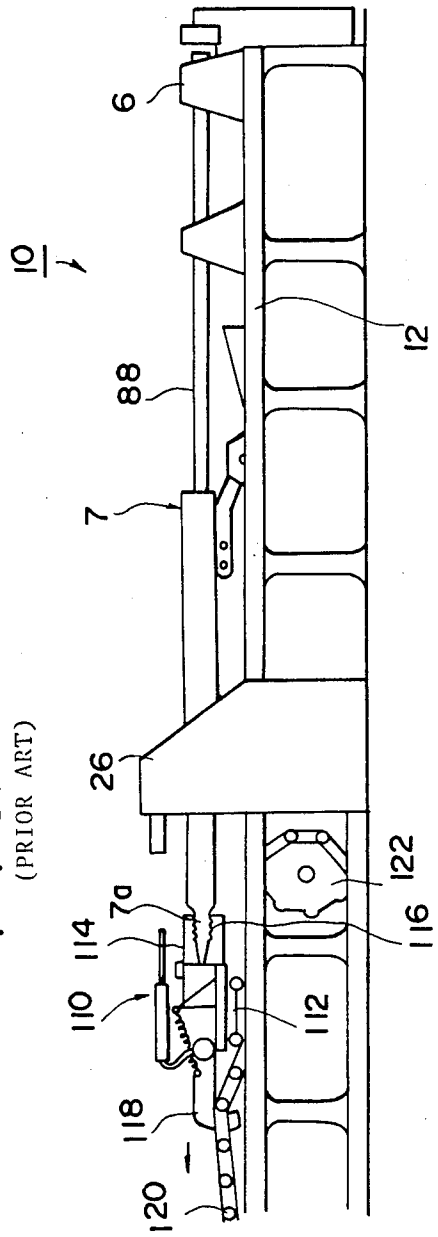


FIG. 2 (a)
(PRIOR ART)

FIG. 2 (b)
(PRIOR ART)

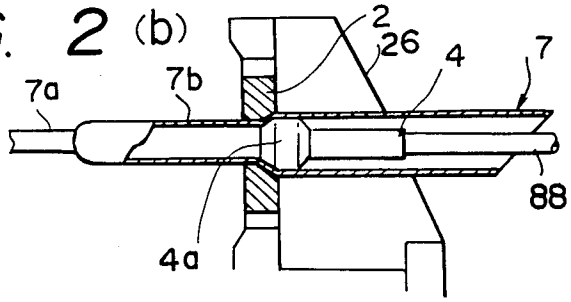


FIG. 3 (a)
(PRIOR ART)

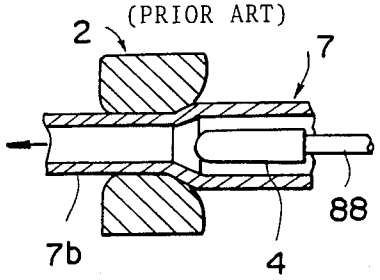


FIG. 3 (b)
(PRIOR ART)

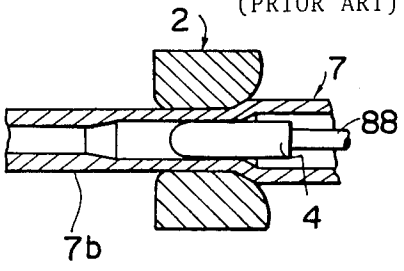


FIG. 4 (a)
(PRIOR ART)

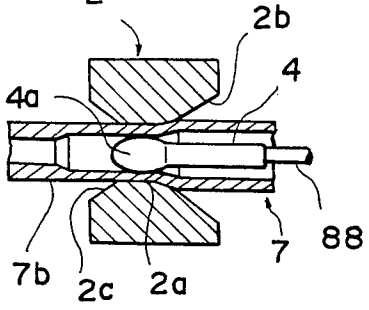


FIG. 4 (b)
(PRIOR ART)

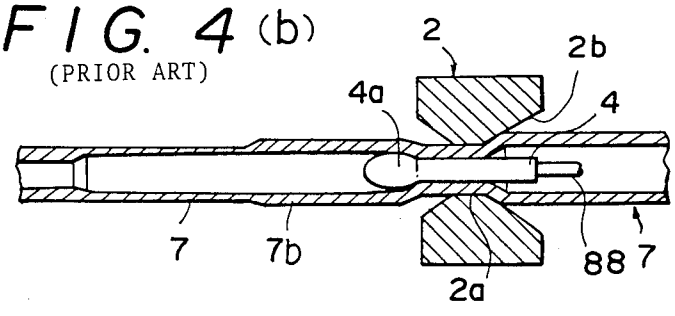
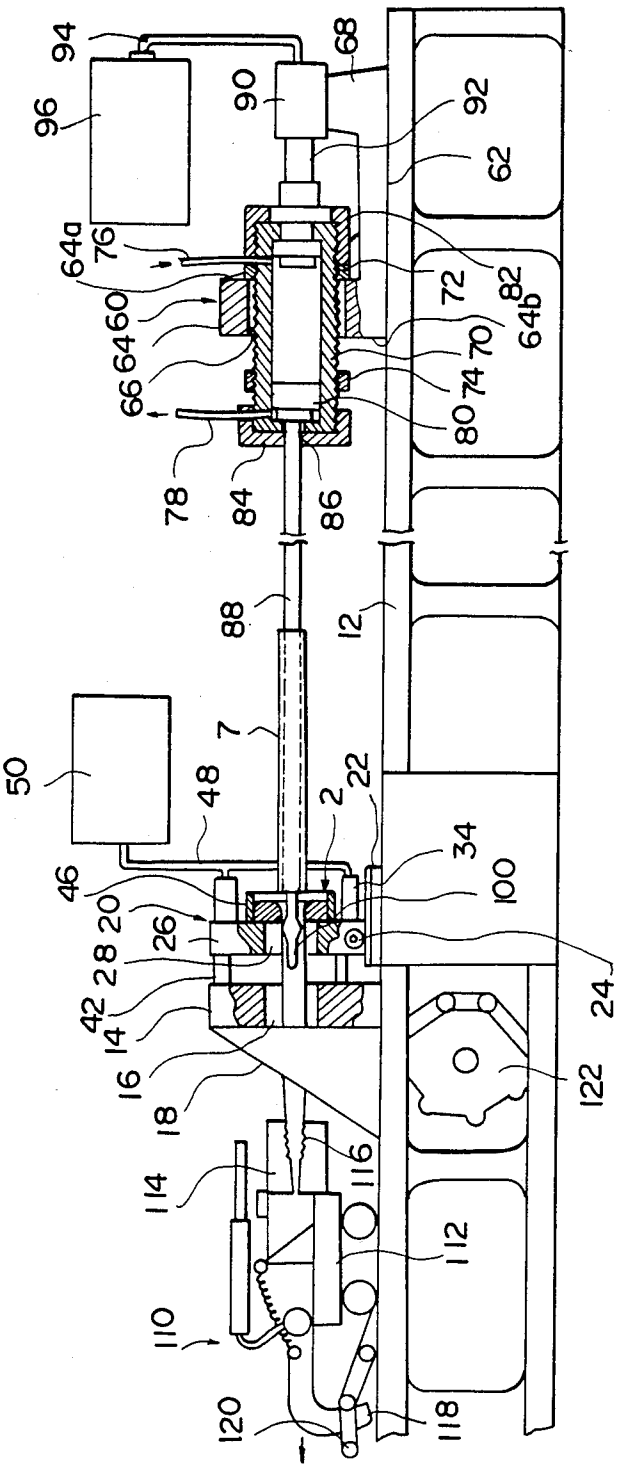


FIG. 5 (a)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96
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92
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64a
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66
64
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82
64b
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78
84
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88
12
7
50
48
2
22
34
100
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20
26
28
42
14
16
18
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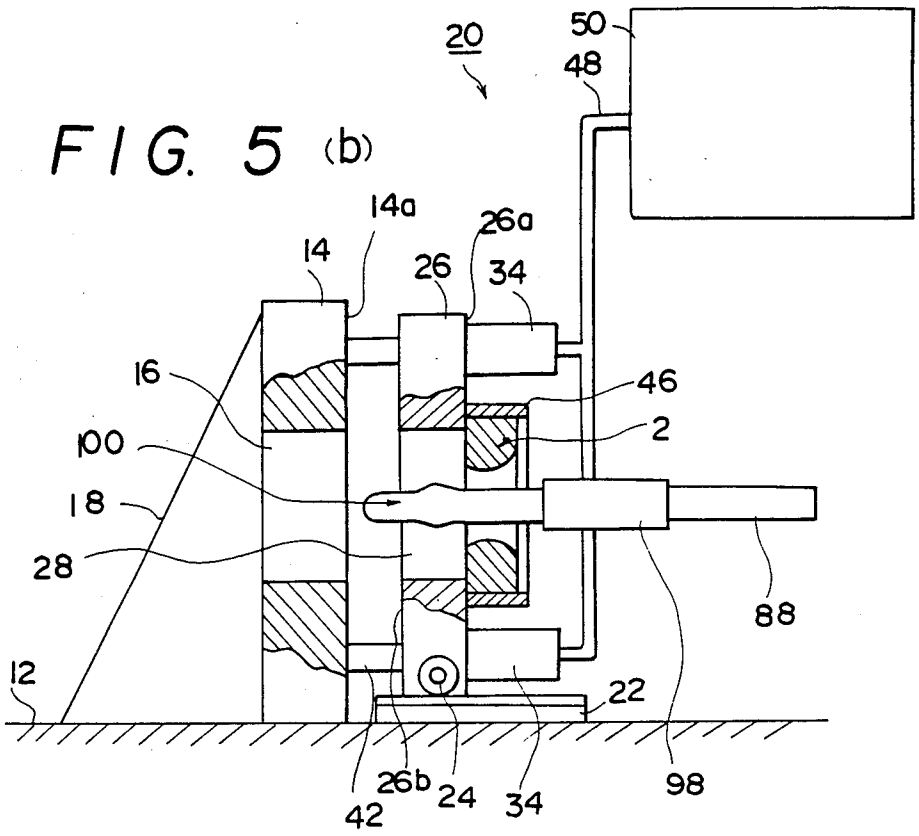
122
116
114
112
110
120
118

FIG. 5 (b)


20
50
48
14a
26a
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26b
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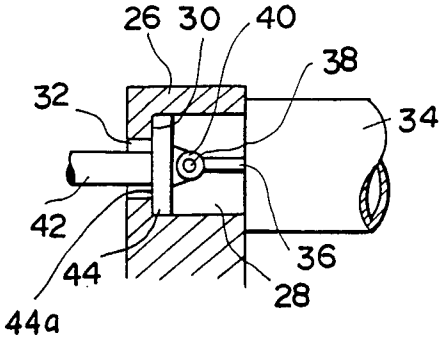
FIG. 5 (c)


26
30
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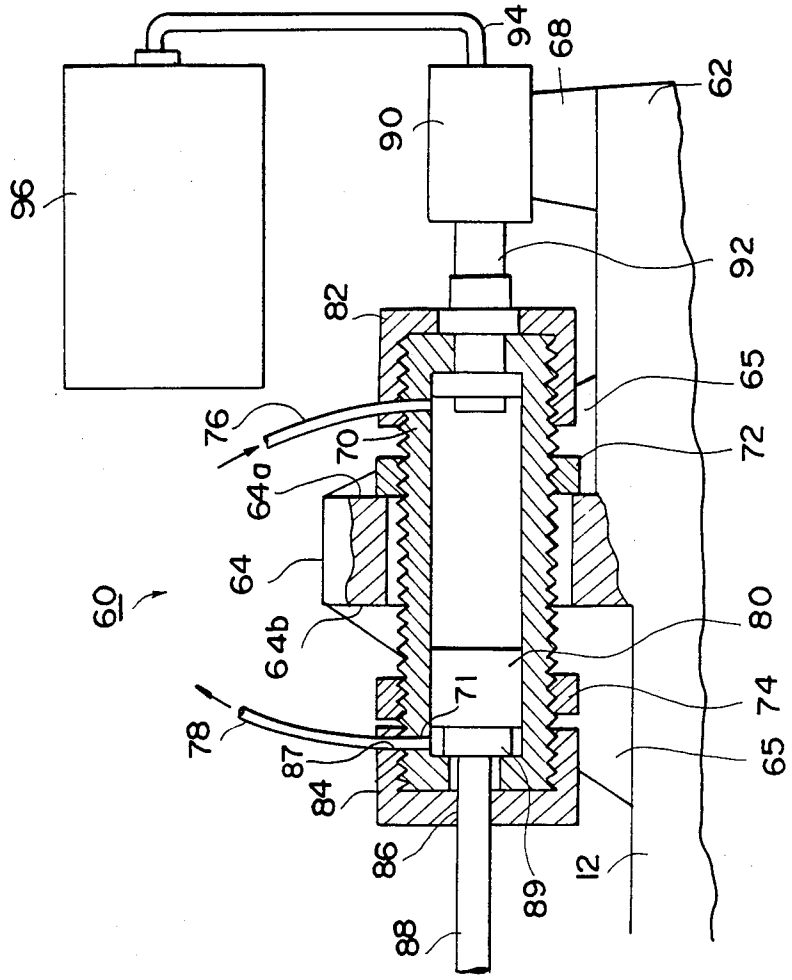
44
28
44a

FIG. 6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84
86
89
12
88

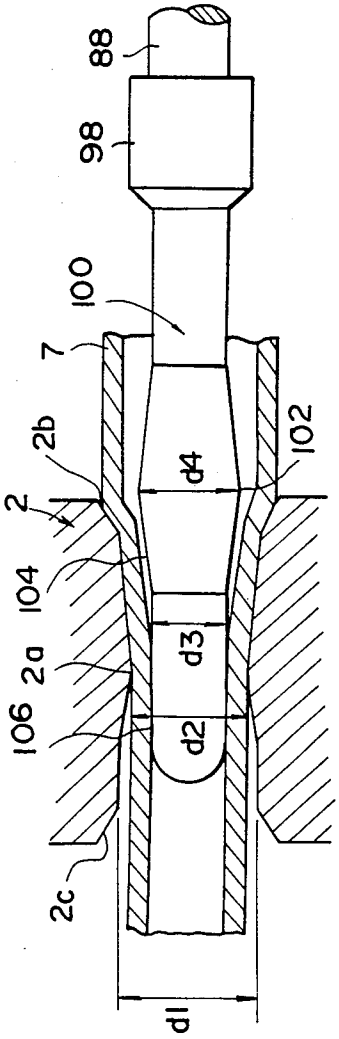
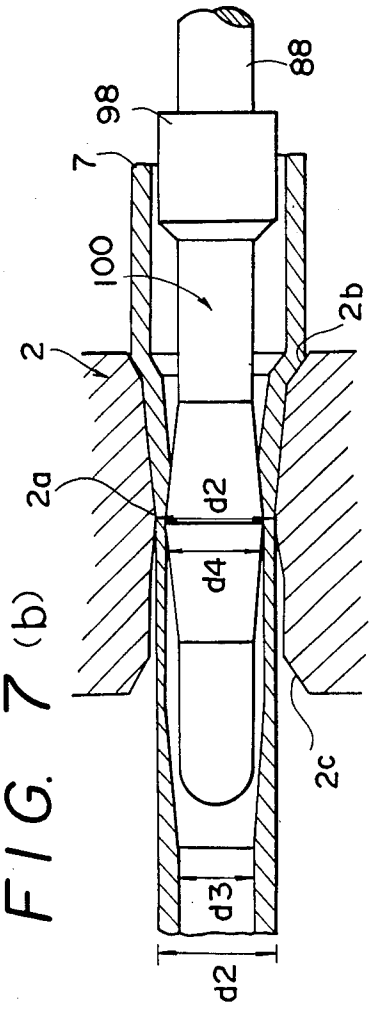

88
98
100
7
2b
2
104
2a
106
2c
d4
d3
d2
d1
102

FIG. 7 (a)


88
98
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2b
2
2a
2c
d2
d4
d3
d2

FIG. 7 (b)

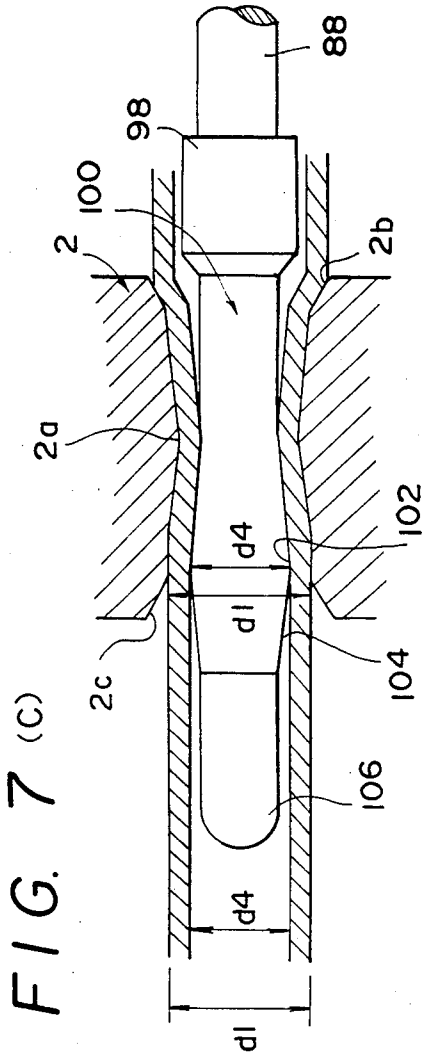


FIG. 7 (C)

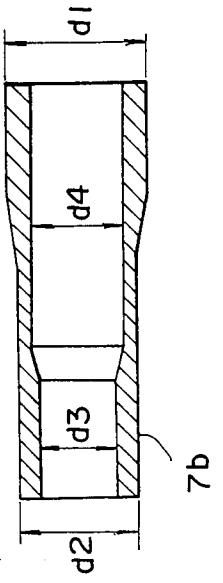


FIG. 8 (b)

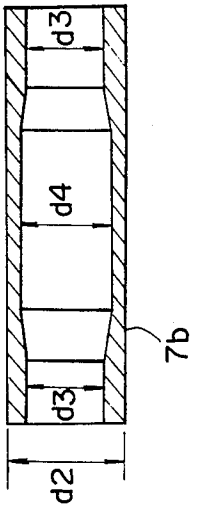


FIG. 8 (a)

FIG. 8 (C)

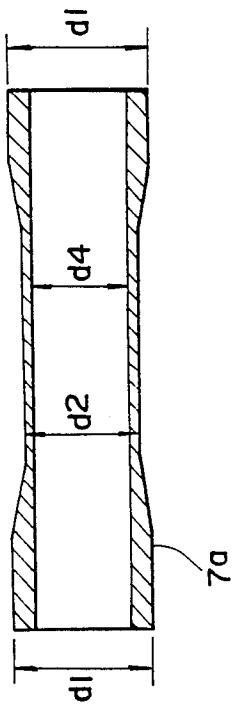
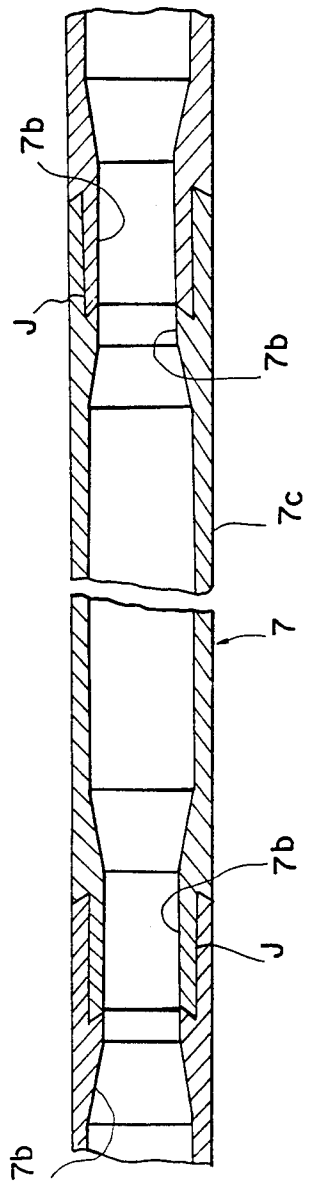


FIG. 9



METHOD OF COLD DRAWING SEAMLESS METAL TUBES EACH HAVING AN UPSET PORTION ON EACH END

CROSS REFERENCE TO A RELATED APPLICATION

This application is a divisional application of U.S. application Ser. No. 599,825, filed Apr. 13, 1984, now U.S. Pat. No. 4,606,212 issued Aug. 19, 1986.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of cold drawing seamless metal tubes each having an upset portion on each end.

These seamless metal tubes are preferably used for drilling tubes, casings, inner rods and outer rods for geological, mineralogical, metallurgical or geothermal research and/or drilling for civil engineering or water wells.

2. Prior Art

With reference to FIGS. 1 to 4(*b*) showing the seamless metal tubes which have been produced by the conventional method using the conventional draw bench, a fot forged thin wall midbody 7*c* of a metal tube is welded at each end with a thick wall end tube 7*b* in order to obtain a large diameter seamless metal tube or pipe 7 having an upset portion 7*b* on each end.

Alternatively, the seamless metal tube may be produced by casting or lathing, but metallic filaments in such a seamless metal tube are axially cut at welded or lathed portions or at blowholes, which are likely to cause cracks in the seamless metal tube after heat treatment at high temperature.

Thus, a method of and a draw bench for cold drawing seamless metal tubes each having an upset portion on each end have been proposed. For example, a small diameter and thin wall seamless metal tube having a diameter of 25–35 mm and a wall thickness of 2.1–3.2 mm, such as for a bicycle framework, may be cold drawn through the draw bench shown in FIGS. 2(*a*) to 4(*b*).

The conventional draw bench, which is particularly shown in FIGS. 2(*a*) and 2(*b*), for drawing such seamless metal tube comprises a bed **12** to be fixed on the floor, a die holder **26** which is mounted at a middle portion on the bed **12**, and a closed periphery reducing die **2** which is concentrically mounted in the die holder **26**. A pair of tongs **6** and a bearing are arranged on the entry side of the bed **12** for horizontally supporting a plug fixing rod **88**.

Secured to a front portion of the rod **88** is a plug **4** which is inserted into the reducing die **2** when drawing.

A draw unit **110** is arranged on the exit side of the bed **12** and comprises a carriage **112** mounted on rollers travelling on the bed **12**, the carriage **112** carrying a hook **118** and a chuck **114** for gripping the front tip 7*a* of the mother tube or workpiece 7. The carriage **112** is driven by an endless chain **120** encompassing a driven sprocket wheel (not shown) mounted on the bed **12**. A driving sprocket wheel is coupled by any convenient means with an electric motor (not shown). The hook **118** is engaged with the endless chain **120** when drawing, and the front tip 7*a* of the mother tube 7 engaged by jaws **116** of the chuck **114** is strongly pulled by the carriage **122** to draw a tube 7 having an upset portion 7*b* on each end.

The embodiments in FIGS. 3(*a*) and 3(*b*) show the conventional manner of drawing seamless metal tubes which have the same outer diameter but unequal inner diameter upset portions on both ends. In FIG. 3(*a*), a plug **4** is held adjacent to a tapered entry in the axial bore of the reducing die **2**, at a clearance from the inner periphery of the mother tube 7, to draw the portion of the tube 7 having a small inner diameter upset portion 7*b* on both ends, while the plug **4** in FIG. 3(*b*) is held right in the bore of the reducing die **2** to draw a tube 7 having a larger inner diameter.

FIGS. 4(*a*) and 4(*b*) show another conventional drawing method.

As shown in FIG. 4(*a*), a reducing die **2** can have an internal surface including an inlet portion 2*b* which tapers forwardly toward a bearing or throat portion 2*a*, and oppositely inclined outlet portion 2*c*. When the enlarged front portion 4*a* of a plug **4** is held right in the bearing portion 2*a* of the reducing die **2**, the mother tube 7 is drawn through the bearing portion 2*a* and over the enlarged front portion 4*a* to form a drawn tube having a small outer diameter.

In FIG. 4(*b*), the enlarged front portion 4*a* of the plug **4** is passed leftwards through the bearing portion 2*a* and located adjacent to the outlet portion 2*c*. Then the mother tube 7 is drawn through the bearing portion 2*a* and around the small diameter portion 4*b* of the plug **4** to reduce the outer diameter of the drawn tube. When the mother tube 7 is further advanced, the inner diameter of the mother tube 7 is widened by the enlarged front portion 4*a* of the plug **4** so as to draw a tube 7 having the same inner diameter as that of the enlarged front portion 4*a* of the plug **4** and having an outer diameter upset portion 7*b* larger than that of the drawn tube 7 produced by means of the reducing die **2** of FIG. 4(*a*).

Seamless metal tubes 7 drawn through conventional reducing dies **2** as described above have the following disadvantages:

(1) The seamless mother tube 7 having a small inner diameter is drawn through the reducing die **2** of FIG. 3(*a*) without any internal radial pressure, thus resulting in corrugation in and around the drawn tube.

(2) In FIG. 4(*b*), the mother tube 7 is drawn through the reducing die **2** with the plug **4** held in the bearing portion 2*a* and in the tube 7 to obtain the drawn tube 7 having one outer diameter but two different inner diameter upset portions 7*b*. The tube drawn through the bearing portion 2*a* and over and around the small diameter portion 4*a* of the plug **4** is widened by the enlarged front portion 4*a* of the plug **4** to obtain a drawn tube similar to that shown in FIGS. 7(*a*), 7(*b*) and 7(*c*), wherein

d_4 denotes a large diameter bearing portion of the plug **4**, d_2 denotes a bearing portion diameter of the reducing die **2**, d_1 denotes a large diameter of the drawn tube 7, and d_3 denotes a small diameter bearing portion of the plug **4** respectively.

Accordingly, d_4 becomes an inner diameter of the drawn tube 7 and d_2 becomes a small outer diameter of the drawn tube 7, but the large diameter d_1 of the drawn tube 7 is not directly related to the bearing portion diameters of the reducing die **2** and the plug **4**, but is given by the following functional formula:

$$d_1 = f(d_2, d_3, d_4)$$

However, we cannot determine the values of d_1, d_2 and d_4 independently. In order to arrive at the most preferable values for d_1, d_2 and d_4, it is necessary to select the values sufficiently near the most suitable value among the various solutions of the functional formula of

$$d_1 = f(d_2, d_3, d_4)$$

We cannot, however, obtain the most suitable values for the diamteers of d_1, d_2 and d_4.

(3) The configuration of the drawn tube is limited to only two kinds, i.e.

(a) one having one outer diameter but two unequal inner diameters;

(b) another having one inner diameter but two unequal outer diameters.

(4) The drawing force of the plug **4** is so small that the plug **4** may be driven in its movement by a hydraulic cylinder, while on the other hand it is necessary to provide a balancing unit or a plurality of hydraulic cylinders to balance the reaction upon the strong drawing force of the plug **4**, thus making the device complicated and expensive.

SUMMARY AND OBJECTS OF THE INVENTION

A principal object of this invention is to provide a novel and improved method of cold drawing a seamless metal tube having an upset portion on each end.

Another object of this invention is to provide a novel and improved method of cold drawing a seamless metal tube wherein a reducing area between a reducing die and a plug is radially changed to draw a seamless metal tube having an upset portion on each end.

Another object of this invention is to provide a method of cold drawing a seamless metal tube wherein the drawing action is sufficiently reliable and reproducible to insure that each and every mother tube is ready to undergo drawing under reduction for forming unequal diameter upset portions on both ends.

Another object of this invention is to provide a method of cold drawing seamless metal tube whereby a reducing die and a plug having unequal diameter bearing portions are movable with each other and are fixed at the selected positions in order to draw a seamless metal tube having an upset portion on each end.

Another object of this invention is to provide a method of cold drawing seamless metal tube having an upset portion on each end whereby the reducing die and the plug are longitudinally movable to a number of different positions but remain at a standstill once they assume the selected positions to obtain a plurality of reducing area between the reducing die and the plug.

Another object of this invention is to provide a method of cold drawing a seamless metal tube having an upset portion on each end without forging, casting or welding.

Another object of this invention is to provide a method of cold drawing a seamless metal tube having an upset portion on each end which has no alteration in the structure, in strength of the upset end portion and of the midbody of the drawn tube, but has dimensional stability in all areas thereof.

Another object of this invention is to provide a method of cold drawing a seamless metal tube having an upset portion on each end which has no scales, but has tighter tolerance, thus enabling the tubes to be thread without prior machining.

Still another object of this invention is to provide a method of cold drawing a seamless metal tube having an upset portion on each end whereby precise threading can be achieved and threading efficiently can be remarkably improved.

BRIEF DESCRIPTION OF DRAWING

The nature of this invention will be clear from the following detailed description of particular embodiments of the proposed method of cold drawing a seamless metal tube having an upset portion on each end when taken with the accompanying drawings, in which:

FIG. **1** is a cross section of a seamless metal tube made by a conventional process such as by casting, lathing or hot forging, with its midbody partially cut away;

FIG. **2**(*a*) is a side elevation of a conventional draw bench, with the chain drive portion of a draw unit partially cut away;

FIG. **2**(*b*) is an enlarged detailed vertical sectional view of a reducing die, a plug and a mother tube shown in FIG. **2**(*a*), particularly showing that the mother tube is being drawn through the reducing die and around the plug;

FIGS. **3**(*a*) and **3**(*b*) are fragmentary axial sectional views of the reducing die and the modified plug showing some conventional drawing steps for drawing seamless metal tubes;

FIGS. **4**(*a*) and **4**(*b*) are similar fragmentary axial sectional views of the reducing die and the modified plug, showing other conventional drawing steps for drawing ordinary seamless metal tubes;

FIG. **5**(*a*) is a side elevation, partly in section, of a draw bench which is used for carrying out the method of this invention;

FIG. **5**(*b*) is a greatly enlarged detailed vertical sectional view of the die control device of the draw bench shown in FIG. **5**(*a*);

FIG. **5**(*c*) is a greatly enlarged detailed vertical sectional view of a hydraulic cylinder which is secured to a rear face of the die holder shown in FIGS. **5**(*a*) and **5**(*b*);

FIG. **6** is a greatly enlarged detailed vertical sectional view of the plug control device;

FIG. **7**(*a*) is an enlarged vertical section of the reducing die, the mother tube and the plug of this invention, with its large diameter bearing of the plug approaching an inlet portion of the reducing die;

FIG. **7**(*b*) is an enlarged vertical section similar to FIG. **7**(*a*), with the large diamater bearing of the plug located at the small diameter bearing portion of the reducing die;

FIG. **7**(*c*) is also an enlarged vertical section similar to FIG. **7**(*a*), with the large diameter bearing of the plug located at the forwardly tapered outlet portion;

FIG. **8**(*a*) is a cross section of a seamless metal tube drawn through the draw bench of this invention, and having an inner upset portion on each end;

FIG. **8**(*b*) is a similar cross section of a seamless metal tube drawn by the method of this invention, and having an inner upset portion on one end and an outer upset portion on another end;

FIG. **8**(*c*) is a similar cross section of a seamless metal tube drawn through the method of this invention, and having an outer upset portion on each end; and

FIG. 9 is a cross section of the seamless metal tubes, partially cut away, which are screw-threadedly joined to each other through the upset portion on each end.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The method of this invention is characterized in that the cross-sectional reducing area between the reducing die and the plug is preferably changed in accordance with the desired forms of a mother tube to be drawn by longitudinally transferring the reducing die and the plug and fixing them at the selected positions.

Proceeding now with a detailed description of the drawings, we turn first to FIGS. 5(*a*) through 6 illustrating this invention. A draw bench **10** for carrying out the method of this invention comprises a bed **12** which is usually fixed on the floor, a front stopper **14** which is mounted at the middle portion on the bed **12** and is reinforced by a reinforcing member **18**, the stopper **14** having a central large opening **16**.

In FIGS. 5(*a*) and 5(*b*), a die control device **20**, which is arranged on the bed **12** adjacent to the front stopper **14**, includes a rail **22** extending longitudinally on the bed **12**, and a carriage **24** arranged movably on the rail **22**. A die holder **26** rigidly secured on the carriage **24** has a large diameter central opening **28**, and a cylindrical holder **46** including a closed periphery reducing die **2** is secured to a rear face of the die holder **26** in line with the central large diameter opening **28** thereof.

A pair of hydraulic cylinders **34** extend in the axial direction at diametrically opposite peripheral regions of the rear face of the die holder **26**, one end portion of each of the hydraulic cylinders penetrating through the die holder **26** and being connected to the rear face of the front stopper **14** by means of a ram **42**.

As particularly shown in FIG. 5(*c*), a pair of axially extending cylindrical recesses **28** are formed in the rear face of the die holder **26** near its outer periphery, and a small opening **32** is formed through the floor **30** of each cavity **28**. A large diameter flange **44** of a respective one of the rams **42** is inserted into each recess **28**, the ram extending through the small opening **32** being connected to the rear of the front stopper **14**.

The front end of the piston **36** of the hydraulic cylinder **34** is coupled to a male lug **40** which is provided at a central rear face of the large diameter flange **44**, and the front end of the hydraulic cylinder **34** is secured to the rear face of the die holder **26** to abut upon the hollow portion **28** thereof.

In this way, the front face **44***a* of the large diameter flange **44** provided at the end of the ram **42** is brought into contact with the innermost portion **30** of the cylindrical hollow portion **28** when the piston (not shown) within the hydraulic cylinder **34** is advanced forwardly.

The hydraulic cylinder **34** produces a pushing force which is larger than a tube drawing force of for instance 150–200 tons. In order to fix the die holder **26** at the desired position, the large diameter flange **44** is preferably brought into contact with the innermost portion **30**. The hydraulic cylinders **34** are connected to a hydraulic unit **50** by a pipe **48**.

A plug control device **60** shown in FIG. **6** is arranged on the bed **12** at the entry side thereof and coaxially with the die control device **20**. The plug control device **60** includes a base **62** which is rigidly mounted on the bed **12**, a rear stopper **64** having a central lateral opening **66**, and a rear post **68**, the rear stopper **64** being reinforced on both sides by a pair of reinforcing members **65**.

A leading screw compressed-air cylinder **70** having a radial small opening **71** through a periphery rotatably and slidably extends through the central lateral opening **66**, and a pair of screw nuts **72** and **74** are threadedly screwed on the extending portions of the compressed-air cylinder **70**.

A rear end cover **82** including a compressed-air supply flexible pipe **76** is threadedly screwed on the rear end of the cylinder **70**, and front cover **84** having a central opening **86** and a radial small opening **87** is threadedly screwed on the front portion of the cylinder **70**. Prior to screwing of the front cover **84**, a rear portion of a push-pull main rod **88** is closely fitted through the central opening **86** of the front cover **84** to allow a large diameter flange **89** to be located within the hollow cylinder **70** when the cover **84** is screwed on the front end of the cylinder **70**. When cover **84** is screwed on cylinder **70**, the small radial opening **71** of the cylinder **70** is coincided with the radial small opening **87**, into which a compressed-air exhaust flexible pipe **78** is connected. The large diameter flange **89** of the push-pull main rod **88** is connected to the piston **80** within the cylinder **70**.

A front portion of a hydraulic cylinder **90** which is laterally mounted on the rear post **68** is coupled to the rear end of the cylinder **70** by a ram **92**, the rear end of which is connected to a hydraulic unit **96** by a pipe **94**.

As shown in FIGS. 7(*a*) to 7(*c*), a plug **100** is secured to a front end portion of the push-pull main rod **88** by a shank **98**, and the plug **100** includes a large diameter bearing portion **102** (d_4), a forwardly tapered portion **104** and a small diameter bearing portion **106** (d_3) which are shaped forwardly in the stated order.

In accordance with the draw bench **10** of this invention, the left screw nut **74** is rotatably brought into contact with the front face **64***b* of the rear stopper **64** to determine the right fixed position, while the right screw nut **72** is rotatably brought into contact with the rear face **64***a* thereof to determine the left fixed position.

For drawing, the reducing die **2** and the plug **100** are respectively transferred to take the fixed positions by the hydraulic units **50** and **96** which are connected thereto by the respective pipes **48** and **94**.

The reducing die **2** has an internal surface including an inlet portion **2***b* which tapers rearwardly, a small diameter bearing or throat portion **2***a* and an oppositely inclined outlet portion **2***c*.

A draw unit **110** is arranged on the exit side of the bed **12** and comprises a carriage **112** mounted on rollers travelling on the bed **12**, the carriage **112** carrying a hook **118** and a chuck **114** for gripping the front tip **7***a* of the mother tube or workpiece **7**. The carriage **112** is driven by an endless chain **120** encompassing a driven sprocket **122** and a driving sprocket wheel (not shown) mounted in the bed **12**.

Drawing operations are schematically shown in FIGS. 7(*a*) to 7(*c*). The die holder **26** is located at the left fixed position as shown in FIG. 5(*a*) to locate the large diameter bearing portion **102** (d_4) of the plug **100** at the rearwardly tapered inlet portion **2***b* as shown in FIG. 7(*a*), while the plug control device **60** is located at the right fixed position in FIG. **6** for drawing the mother tube **7**.

In FIG. 7(*b*), the die holder **26** is located at the left fixed position and the plug fixing main rod **88** is also located at the left fixed position to fix the large diameter

bearing portion **102** (d_4) of the plug **100** at the throat portion **2***a* of the reducing die **2**, thus drawing the mother tube **7** having an inner peripheral upset portion **7***b* on each end.

In FIG. **7**(*c*), the die holder **26** and plug fixing main rod **88** are relatively located so that the large diameter bearing portion **102** is located at the outlet portion **2***c* so that the tube is drawn out with an outer diameter d*l* and an inner diameter d**4**.

The drawn tube **7** having an inner peripheral upset portion **7***b* on one end and an outer peripheral upset portion **7***b* on another end shown in FIG. **8**(*b*) can be obtained through the continuous successive steps shown in FIGS. **7**(*a*), **7**(*b*) and **7**(*c*). The drawn tube **7** having an inner peripheral upset portion **7***b* on each end can be formed by successively performing the steps shown in FIGS. **7**(*a*), **7**(*b*) and **7**(*a*).

Finally, the drawn tube having outer peripheral upset portions **7***b* on both ends shown in FIG. **8**(*c*) can be formed by successively performing the steps shown in FIGS. **7**(*c*), **7**(*b*) and **7**(*c*).

The die holder **26** and the plug fixing main rod **88** are driven to move with each other by means of the hydraulic units **50** and **96** which are mounted on the bed **12**, taking account of the speeds among the drawn tube **7**, the reducing die **2** and the plug **100**.

After drawing, the plug **100** is again brought back to the starting position by the plug control device **60**, while the die holder **26** is also returned to the starting position by the die control device **20**.

An example of the drawn tube **7** having an upset portion **7***b* on each end embodying the novel feature of this invention is given below.

Material	Mn—Cr—Mo steel alloy
Heat treatment	Quenching and tempering finally resulting in martensitic structure.
Size after drawing:	
Outer diameter	88.0 mm
Thick wall thickness	6.6 mm
Thin wall thickness	5.0 mm
Length	2–6 m
Shore hardness	43
Strength	90 Kg/mm^2
Joint of each drawn tube	Joined at acme tapered screw thread of the upset end portion.
Use	Surveying for underground resource such as uranium, metals, etc. or for geological surveying.
Rotation	800–1000 rpm
Depth	Boring 1000–1500 m under the ground.
Other benefits	Mud and slurry are smoothly circulated.

As is clear from the foregoing description and the example, the preferred drawing method in accordance with this invention considerably improves the drawing steps, drawing rate, reduction of area and the like, and may advantageously be used to draw seamless metal tubes having upset portions at both ends.

While an embodiment of this invention has been described, it is obvious that variations and modifications are possible without departing from the invention. It is desired to cover all such forms of the invention as would be apparent to one skilled in the art, and that come within the scope of the appended claims.

We claim:

1. A method of cold drawing a seamless metal tube having an upset portion on each end, comprising the steps of:

defining a reducing area between first and second relatively movable members, the first member being a closed periphery reducing die and the second member being a plug secured to a front end portion of a main push-pull rod, the reducing die having an internal surface including a rearward inlet portion which tapers rearwardly, a forward outlet portion which tapers forwardly, and a small diameter bearing portion between the inlet and outlet portions, the plug having a large diameter bearing portion between a rearward rearwardly tapered portion and a forward small diameter bearing portion;

moving the reducing die and the plug longitudinally with respect to each other at least twice to vary the size of the reducing area and fixing the reducing die and the plug in three different positions selected from first, second and third relative positions, the forward small diameter bearing portion of the plug being radially aligned with the small diameter bearing portion of the die in the first relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a first inner diameter and a first outer diameter, the large diameter bearing portion of the plug being radially aligned with the small diameter bearing portion of the die in the second relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a second inner diameter greater than the first inner diameter and a second outer diameter equal to said first outer diameter, and the large diameter bearing portion of the plug being radially aligned with the outlet portion of the die in the third relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a third inner diameter equal to the second inner diameter and a third outer diameter greater than the first and second outer diameters; and

successively drawing a mother tube through the die and around the plug through the reducing area in three steps, each of said steps being performed when the plug and die are in a different one of the first, second and third positions, to thereby successively form first, second and third tube portions having inner and outer diameters corresponding to the reducing area during each of the three steps, at least one of the first and third tube portions forming an upset portion with the second tube portion therebetween, two of the tube portions having different inner diameters and different outer diameters.

2. A method of cold drawing a seamless metal tube having an upset portion on each end, comprising the steps of:

defining a reducing area between first and second relatively movable members, the first member being a closed periphery reducing die and the second member being a plug secured to a front end portion of a main push-pull rod, the reducing die having an internal surface including a rearward inlet portion which tapers rearwardly, a forward outlet portion which tapers forwardly, and a small diameter bearing portion between the inlet and outlet portions, the plug having a large diameter

bearing portion between a rearward rearwardly tapered portion and a forward small diameter bearing portion;

moving the reducing die and plug longitudinally with respect to each other at least twice to vary the size of the reducing area and fixing the reducing die and the plug in three different positions selected from first, second and third relative positions, the forward small diameter bearing portion of the plug being radially aligned with the small diameter bearing portion of the die in the first relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a first inner diameter and a first outer diameter, the large diameter bearing portion of the plug being radially aligned with the small diameter bearing portion of the die in the second relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a second inner diameter greater than the first inner diameter and a second outer diameter equal to said first outer diameter, and a large diameter bearing portion of the plug being radially aligned with the outlet portion of the die in the third relative position so that the inner and outer peripheries of the reducing area therebetween respectively have a third inner diameter equal to the second inner diameter and a third outer diameter greater than the first and second outer diameters; and

successively drawing a mother tube through the die and around the plug through the reducing area in three steps, each of said steps being performed when the plug and die are fixed in a different one of the first, second and third positions, including the steps of relatively fixing the plug and die in one of the first and third relative positions during the first step, then relatively moving the plug and die to the second relative position and relatively fixing the plug and die in the second relative position during the second step, and then relatively moving the plug and die to the other of the first and third relative positions and relatively fixing the plug and die in said other of the first and third relative positions during the third step, to thereby successively form first, second and third tube portions having inner and outer diameters corresponding to the reducing area during each of the three steps, the first and third tube portions forming upset portions with the second tube portion therebetween, whereby there is formed a tube having an outer upset portion and an inner upset portion at the first and third tube portions at the respective opposite ends of the second tube portion.

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